may install and maintain numerical control equipment—computer controlled machine tools that fabricate manufacturing parts. This machinery requires special care and knowledge, so millwrights often work closely with computer or electronics experts, electricians, engineers, and manufacturer's representatives to install it. (Statements on electronics repairers, commercial and industrial equipment, as well as electricians, appear elsewhere in the *Handbook*.)

Working Conditions
Working conditions vary by industry. Millwrights employed in manufacturing often work in a typical shop setting and use protective equipment to avoid common hazards. For example, protective devices, such as safety belts, protective glasses, and hard hats may prevent injuries from falling objects or machinery. Those in construction may work outdoors in uncomfortable weather conditions.

Millwrights may work independently or as part of a team. They must work quickly and precisely, because disabled machinery costs a company time and money. Many millwrights work overtime; nearly half report working more than 40 hours during a typical week. During power outages, millwrights have been assigned overtime and shift work, because of shift requirements.

Employment
Millwrights held about 82,000 jobs in 1998. Most worked in manufacturing, primarily in durable goods industries, such as motor vehicles and equipment and basic steel products. Other millwrights were employed primarily by construction firms and machining and equipment wholesalers; many of these workers are contractors. Although millwrights work in every State, employment is concentrated in heavily industrialized areas.

Training, Other Qualifications, and Advancement
Millwrights are responsible for the mechanical maintenance, repair, overhaul, and installation of machinery, so training is varied and extensive. Millwrights normally train for 4 years—through apprenticeship programs that combine on-the-job training with classroom instruction—or through community college coupled with informal on-the-job training. These programs include training in dismantling, moving, erecting, and repairing machinery. Trainees may also work with concrete and receive instruction in related skills, such as carpentry, welding, and sheet-metal work. Classroom instruction is provided in mathematics, blueprint reading, hydraulics, electricity, computers, and electronics.

Employers prefer applicants with a high school diploma or equivalency and some vocational training or experience. Courses in science, mathematics, mechanical drawing, computers, and machine shop practice are useful. Millwrights are expected to keep their skills up-to-date and may need additional training on technological advances, such as laser shaft alignment and vibration analysis.

Because millwrights assemble and disassemble complicated machinery, mechanical aptitude is very important. Strength and agility also are necessary, because the work can require a considerable amount of lifting and climbing. Millwrights need good interpersonal and communication abilities to work as part of a team and to be able to give detailed instructions to others.

Advancement for millwrights usually takes the form of higher wages. Some advance to supervisor or superintendent, whereas others may become self-employed contractors.

Job Outlook
Employment of millwrights is projected to decline slightly through the year 2008. Nevertheless, skilled applicants should have good job opportunities, because millwrights will be needed to maintain and repair existing machinery, dismantle old machinery, and install new equipment. Job openings will stem from the need to replace experienced millwrights who transfer to other occupations or leave the labor force.

Automation, technological advances, and the growing utilization of lower-paid workers will contribute to the decline in employment. As automation of machinery becomes more widespread, there is a greater need for repair work than for the installation of new machinery. Millwrights are becoming more productive through the use of technologies like hydraulic torque wrenches, ultrasonic measuring tools, and laser shaft alignment, as these technologies allow fewer workers to perform more work. In addition, the demand for millwrights will be adversely affected, as lower-paid workers, such as electronics technicians and industrial machinery mechanics, increasingly assume some installation and maintenance duties. Nevertheless, historical employment of millwrights has been fairly stable, and the growing use of machinery in the Nation's economy should ensure that the employment decline will be small.

Earnings
Median hourly earnings of millwrights were $17.76 in 1998. The middle 50 percent earned between $14.11 and $21.80. The lowest 10 percent earned less than $11.35 and the highest 10 percent earned more than $24.38. Median hourly earnings in the industries employing the largest numbers of millwrights in 1997 are shown below:

Motor vehicles and equipment	$21.60
Paper mills	18.60
Miscellaneous special trade contractors	17.00

Earnings vary by industry and geographic location. About 58 percent of millwrights belong to labor unions, one of the highest rates of membership in the economy.

Related Occupations
To set up machinery for use in a plant, millwrights must know how to use hoisting devices and how to assemble, disassemble, and sometimes repair machinery. Other workers with similar job duties include industrial machinery repairers; aircraft mechanics and service technicians; ironworkers; machine assemblers; and mobile heavy equipment, diesel, and farm equipment mechanics.

Sources of Additional Information
For further information on apprenticeship programs, write to the Apprenticeship Council of your State's labor department, local offices of your State employment service, or local firms that employ millwrights. In addition, you may contact:

☛ The United Brotherhood of Carpenters and Joiners of America, 101 Constitution Ave. NW., Washington DC 20001.

☛ Associated General Contractors of America, 1957 E St. NW., Washington, DC 20006. Internet: **http://www.agc.org**

☛ The National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**

☛ The Precision Machined Products Association, 6700 West Snowville Rd., Brecksville, OH 44141. Internet: **http://www.pmpa.org**

Mobile Heavy Equipment Mechanics

(O*NET 85314)

Significant Points

- Opportunities should be good for persons with advanced knowledge of electronics and hydraulics.
- This occupation offers relatively high wages and the challenge of skilled repair work.
- National certification is the recognized standard of achievement for mobile heavy equipment mechanics.

Nature of the Work
Mobile heavy equipment is indispensable to construction, logging, surface mining, and other industrial activities. Various types of equipment grade land, lift beams, and dig earth to pave the way for development.

Mobile heavy equipment mechanics repair and maintain the engines, transmissions, hydraulics, and electrical systems powering graders, backhoes, and stripping and loading shovels. (For information on mechanics specializing in diesel engines, see the statement on diesel mechanics and service technicians elsewhere in the *Handbook*.)

Mobile heavy equipment mechanics typically work for construction equipment distributor firms, large construction companies, local and Federal governments, or other organizations operating and maintaining heavy machinery and equipment fleets. They perform routine maintenance checks on diesel engines, transmission components, and brake systems, to ensure safety and longevity of the equipment. Maintenance checks and feedback from equipment operators usually alert mechanics to problems. With modern heavy equipment, hand-held computers can be plugged into on-board computers to diagnose any component needing adjustment or repair. After locating the problem, these technicians rely on their training and experience to use the best possible technique to solve the problem. If necessary, they may partially dismantle the component to examine parts for damage or excessive wear. Then, using hand-held tools, they repair, replace, clean, and lubricate parts, as necessary. After reassembling the component and testing it for safety, mechanics put it back into the equipment and return the equipment to the field.

Many types of mobile heavy equipment use hydraulics to raise and lower movable parts, such as scoops, shovels, log forks, and scraper blades. Repairing malfunctioning hydraulic components is an important responsibility of mobile heavy equipment mechanics. When components lose power, mechanics examine them for hydraulic fluid leaks, ruptured hoses, or worn gaskets on fluid reservoirs. Occasionally, the equipment requires extensive repairs, such as replacing a defective hydraulic pump.

In addition to routine maintenance checks, mobile heavy equipment mechanics perform a variety of other repairs. They diagnose electrical problems and adjust or replace defective electronic components. They also disassemble and repair undercarriages and track assemblies. Occasionally, mechanics weld broken equipment frames and structural parts, using electric or gas welders.

Many mechanics work in repair shops for construction contractors, local government road maintenance departments, or logging and mining companies. They typically perform the routine maintenance and minor repairs necessary to keep equipment in operation. Mechanics in large repair shops—particularly those of mobile heavy equipment dealers and the Federal Government—perform more difficult repairs. These repairs include rebuilding or replacing engines, repairing hydraulic fluid pumps, and correcting electrical problems.

It is common for mechanics in some large shops to specialize in one or two types of work. For example, a shop may have individual specialists in major engine repair, transmission work, electrical systems, and suspension or brake systems. The technology used in heavy equipment is becoming more sophisticated with the increased use of electronic and computer-controlled components. Training in electronics is essential for these mechanics, to make engine adjustments and to diagnose problems. Training in the use of hand-held computers is also necessary, because computers serve as the link between mechanic and vehicle and help mechanics diagnose problems and adjust engine functions.

Mobile heavy equipment mechanics may partially dismantle a component to examine parts for damage or excessive wear.

Mobile heavy equipment mechanics use a variety of tools in their work. They use power tools, such as pneumatic wrenches to remove bolts quickly, machine tools like lathes and grinding machines to rebuild brakes, welding and flame-cutting equipment to remove and repair exhaust systems, and jacks and hoists to lift and move large parts. Common handtools—screwdrivers, pliers, and wrenches—are used to work on small parts and to get at hard-to-reach places. Heavy equipment mechanics also use a variety of computerized testing equipment to pinpoint and analyze malfunctions in electrical systems and engines. For example, they use tachometers and dynamometers to locate engine malfunctions. When working on electrical systems, heavy equipment mechanics use ohmmeters, ammeters, and voltmeters.

Working Conditions

Mobile heavy equipment mechanics usually work indoors, although many make repairs at the work site. Mechanics often lift heavy parts and tools, handle greasy and dirty parts, and stand or lie in awkward positions, to repair vehicles and equipment. Minor cuts, burns, and bruises are common; but serious accidents are normally avoided, when the shop is kept clean and orderly and safety practices are observed. Mechanics usually work in well-lighted, heated, and ventilated areas. However, some shops are drafty and noisy. Many employers provide uniforms, locker rooms, and shower facilities.

When mobile heavy equipment breaks down at a construction site, it may be too difficult or expensive to bring it into a repair shop, so the shop often sends a field service mechanic to the job site to make repairs. Field service mechanics work outdoors and spend much of their time away from the shop. Generally, more experienced mobile heavy equipment mechanics specialize in field service. They usually drive trucks specially equipped with replacement parts and tools. On occasion, they must travel many miles to reach disabled machinery. Field mechanics normally earn a higher wage than their counterparts, because they are required to make on-the-spot decisions necessary to serve their customers.

Employment

Mobile heavy equipment mechanics held about 106,000 jobs in 1998. More than 30 percent were employed by mobile heavy equipment dealers and distributors. Nearly 20 percent worked for construction contractors; and about 18 percent were employed by Federal, State, and local governments. Other mobile heavy equipment mechanics worked for surface mine operators, public utility companies, or heavy equipment rental and leasing companies. Still others repaired equipment for machinery manufacturers, airlines, railroads, steel mills, or oil and gas field companies. Fewer than 1 out of 20 mobile heavy equipment mechanics was self-employed.

Nearly every section of the country employs mobile heavy equipment mechanics, though most work in towns and cities where equipment dealers, equipment rental and leasing companies, and construction companies have repair facilities.

Training, Other Qualifications, and Advancement

Although many persons qualify for heavy equipment mechanic jobs through years of on-the-job training, most employers prefer that applicants complete a formal diesel or heavy equipment mechanic training program after graduating from high school. They seek persons with mechanical aptitude who are knowledgeable about the fundamentals of diesel engines, transmissions, electrical systems, and hydraulics. Additionally, the constant change in equipment technology makes it necessary for mechanics to be flexible and have the capacity to learn new skills quickly.

Many community colleges and vocational schools offer programs in diesel mechanics or automotive repair. Some tailor programs to heavy equipment mechanics. These programs educate the student in the basics of analysis and diagnostic techniques, electronics, and hydraulics. The increased use of electronics and computers makes training in the fundamentals of electronics an essential tool for new mobile heavy equipment mechanics. Some 1- to 2-year programs lead to a certificate of completion, whereas others lead to an associate degree in diesel or heavy equipment mechanics. These programs provide a basic foundation in the components of diesel and heavy equipment technology. These programs also enable trainee mechanics to advance more rapidly to the journey, or experienced worker, level.

A combination of formal and on-the-job training prepares trainee mechanics with the knowledge to efficiently service and repair equipment handled by a shop. Most beginners perform routine service tasks and make minor repairs, after a few months' experience. They advance to harder jobs, as they prove their ability and competence. After trainees master the repair and service of diesel engines, they learn to work on related components, such as brakes, transmissions, and electrical systems. Generally, a mechanic with at least 3 to 4 years of on-the-job experience is accepted as a fully qualified heavy equipment mechanic.

Many employers send trainee mechanics to training sessions conducted by heavy equipment manufacturers. These sessions, which typically last up to 1 week, provide intensive instruction in the repair of a manufacturer's equipment. Some sessions focus on particular components found in all of the manufacturer's equipment, such as diesel engines, transmissions, axles, and electrical systems. Other sessions focus on particular types of equipment, such as crawler-loaders and crawler-dozers. As they progress, trainees may periodically attend additional training sessions. When appropriate, experienced mechanics attend training sessions, to gain familiarity with new technology or with types of equipment they have never repaired.

High school courses in automobile mechanics, physics, chemistry, and mathematics provide a strong foundation for a career as a mechanic. It is also essential for mechanics to be able to read, interpret, and comprehend service manuals, to keep abreast of engineering changes. Experience working on diesel engines and heavy equipment acquired in the Armed Forces also is valuable.

Voluntary certification by the National Institute for Automotive Service Excellence (ASE) is recognized as the standard of achievement for mobile heavy equipment mechanics. Mechanics may be certified as a Master Heavy-Duty Diesel Technician or in one or more of six different areas of heavy-duty equipment repair: Brakes, gasoline engines, diesel engines, drive trains, electrical systems, and suspension and steering. For certification in each area, mechanics must pass a written examination and have at least 2 years' experience. High school, vocational or trade school, or community or junior college training in gasoline or diesel engine repair may substitute for up to 1 year's experience. To remain certified, technicians must retest every 5 years. This ensures that mechanics and service technicians keep up with changing technology.

The most important work possessions of mechanics are their hand tools. Mobile heavy equipment mechanics typically buy their own hand tools, and many experienced mechanics have thousands of dollars invested in them. Employers typically furnish expensive power tools, computerized engine analyzers, and other diagnostic equipment; but hand tools are normally accumulated with experience.

Experienced mechanics may advance to field service jobs, where they have a greater opportunity to tackle problems independently and earn additional pay. Mechanics with leadership ability may become shop supervisors or service managers. Some mechanics open their own repair shops or invest in a franchise.

Job Outlook

Opportunities for heavy equipment mechanic jobs should be good for persons who have completed formal training programs in diesel or heavy equipment mechanics. This is due more to a lack of qualified entrants into the occupation than growth in available jobs. Persons without formal training are expected to encounter growing difficulty entering this occupation.

Employment of mobile heavy equipment mechanics is expected to grow more slowly than the average for all occupations through the year 2008. Increasing numbers of mechanics will be required to support growth in the construction industry, equipment dealers, and rental and leasing companies. As equipment becomes more complex, repairs increasingly must be made by specially trained mechanics.

Because of the nature of construction activity, demand for mobile heavy equipment mechanics follows the Nation's economic cycle. As the economy expands, construction activity increases, resulting in the use of more mobile heavy equipment. More equipment is needed to grade construction sites, excavate basements, and lay water and sewer lines, increasing the need for periodic service and repair. In addition, the construction and repair of highways and bridges also requires more mechanics to service equipment.

Construction and mining are particularly sensitive to changes in the level of economic activity; therefore, mobile heavy equipment may be idled during downturns. In addition, winter is traditionally the slow season for construction activity, particularly in cold regions. Few mechanics may be needed during periods when equipment is used less; however, employers usually try to retain experienced workers. Employers may be reluctant to hire inexperienced workers during slow periods though.

Earnings

Median annual earnings of mobile heavy equipment mechanics were $31,520 in 1998. The middle 50 percent earned between $25,050 and $38,340 a year. The lowest 10 percent earned less than $20,950 and the highest 10 percent earned more than $46,500 a year. Median annual earnings in the industries employing the largest number of mobile heavy equipment mechanics in 1997 were as follows:

Federal government	$34,800
Machinery, equipment, and supplies	29,100
Miscellaneous equipment rental and leasing	28,800
Heavy construction, except highway	28,300
Miscellaneous repair shops	27,000

About one third of all mobile heavy equipment mechanics are members of unions including the International Association of Machinists and Aerospace Workers, the International Union of Operating Engineers, and the International Brotherhood of Teamsters.

Related Occupations

Workers in other occupations who repair and service diesel-powered vehicles and heavy equipment include rail car repairers, farm equipment mechanics, and diesel mechanics and service technicians. Other related occupations include motorcycle, boat, small engine, and heating, air-conditioning, and refrigeration mechanics.

Sources of Additional Information

More details about work opportunities for mobile heavy equipment mechanics may be obtained from local mobile heavy equipment dealers and distributors, construction contractors, and government agencies. Local offices of the State employment service may also have information on work opportunities and training programs.

For general information about a career as a mobile heavy equipment mechanic, contact:

☛ The Equipment Maintenance Counsel, 2020 Lake Shore Ct., Sanger, TX 76266.

☛ Specialized Carriers and Rigging Association, 2750 Prosperity Ave., Suite 620, Fairfax, VA 22031-4312. Internet: **http://www.scranet.org**

☛ The AED Foundation (Associated Equipment Dealers affiliate), 615 W. 22nd St., Oak Brook, IL 60523.
Internet: **http://www.aednet.org/aedf**

For a directory of public training programs for mobile heavy equipment mechanics, contact:

☛ SkillsUSA-VICA, P.O. Box 3000, 1401 James Monroe Hwy., Leesburg, VA 22075. Telephone (toll free): 1-800-321-VICA.
Internet: **http://www.skillsusa.org**

A list of certified diesel mechanic training programs can be obtained from:

☛ National Automotive Technician Education Foundation (NATEF), 13505 Dulles Technology Dr., Herndon, VA 20171-3421.
Internet: **http://www.natef.org**

Information on certification as a heavy-duty diesel mechanic is available from:

☛ Automotive Service Excellence (ASE), 13505 Dulles Technology Dr., Herndon, VA 20171-3421.
Internet: **http://www.asecert.org**

Motorcycle, Boat, and Small-Engine Mechanics

(O*NET 85116B, 85308, 85328A, and 85328B)

Significant Points

- Employment is expected to grow slowly, but persons with formal mechanic training should enjoy good job prospects.
- Because the use of motorcycles, boats, and outdoor power equipment is seasonal in many areas, mechanics may service other types of equipment or work reduced hours in the winter.

Nature of the Work

Though smaller, engines powering motorcycles, boats, and lawn and garden equipment share many characteristics with their larger counterparts, including breakdowns. Motorcycle, boat, and small-engine mechanics repair and service power equipment ranging from racing motorcycles to chain saws.

Small engines, like large engines, require periodic service to minimize the chance of breakdowns and to keep them operating at peak performance. During routine equipment maintenance, mechanics follow a checklist including the inspection and cleaning of brakes, electrical systems, plugs, carburetors, and other parts. Following inspection, mechanics usually repair or adjust parts that do not work properly, or replace unfixable parts. Routine maintenance is normally a major part of the mechanic's work.

When equipment breakdowns occur, mechanics use various techniques to diagnose the source and extent of the problem. The mark of a skilled mechanic is the ability to diagnose mechanical, fuel, and electrical problems, and to make repairs in a minimal amount of time. Quick and accurate diagnosis requires problem-solving ability and a thorough knowledge of the equipment's operation.

In larger repair shops, mechanics may use special computerized diagnostic testing equipment as a preliminary tool in analyzing equipment. These computers provide a systematic performance report of various components to compare them to normal ratings. After pinpointing the problem, the mechanic makes the needed adjustments, repairs, or replacements. Some jobs require minor adjustments or the replacement of a single item, such as a carburetor or fuel pump. In contrast, a complete engine overhaul requires a number of hours to disassemble the engine and replace worn valves, pistons, bearings, and other internal parts. Some highly skilled mechanics use highly specialized components and the latest computerized equipment to customize and tune motorcycles and boats for racing.

Motorcycle, boat, and small-engine mechanics use common handtools such as wrenches, pliers, and screwdrivers. They also use power tools, such as drills and grinders when customized repairs warrant.

Motorcycle, boat, and small engine mechanics follow a checklist, including the inspection and cleaning of engine parts during routine equipment maintenance.

Computerized engine analyzers, compression gauges, ammeters and voltmeters, and other testing devices help mechanics locate faulty parts and tune engines. Hoists may be used to lift heavy equipment such as motorcycles, snowmobiles, or boats. Mechanics often refer to service manuals for detailed directions and specifications while performing repairs.

Motorcycle mechanics repair and overhaul motorcycles, motor scooters, mopeds, and all-terrain vehicles. Besides engines, they may work on transmissions, brakes, and ignition systems, and make minor body repairs. Mechanics usually specialize in the service and repair of one type of equipment, although they may work on closely related products. Mechanics may only service a few makes and models of motorcycles because usually the dealers only service the products they sell.

Boat mechanics, or *marine equipment mechanics*, repair and adjust the engines and electrical and mechanical equipment of inboard and outboard marine engines. Most small boats have portable outboard engines that are removed and brought into the repair shop. Larger craft, such as cabin cruisers and commercial fishing boats, are powered by diesel or gasoline inboard or inboard-outboard engines, which are only removed for major overhauls. Most of these repairs are performed at the docks or marinas. Boat mechanics may also work on propellers, steering mechanisms, marine plumbing, and other boat equipment.

Small-engine mechanics service and repair outdoor power equipment such as lawnmowers, garden tractors, edge trimmers, and chain saws. They may also occasionally work on portable generators and go-carts. In addition, small-engine mechanics in northern parts of the